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THE FUNCTION OF RESEARCH IN ENGINEERING EDUCATION[1]

By Professor DUGALD C. JACKSON
MASSACHUSETTS INSTITUTE OF TECHNOLOGY

. . . . to sift the grain from chaff,
Get truth and falsehood known and named as such.

MORE than thirty-five years ago Dr. Robert H. Thurston, then director of Sibley College, was a guest at the University of Wisconsin where I was a youthful and rather new member of the faculty trying to build up suitable laboratories of electrical engineering with inadequate funds. We had much extemporization by teachers and students in the use of equipment. This brought to the surface the peculiarities of each piece of apparatus used in unusual relations, and we were having a grand time experimentally determining the reasons for various observed phenomena which hitherto had not been fully explained. Dr. Thurston walked about our few and meager machines while I told him what we were doing with them and how they served as elements of student work. Then he simply remarked that he was pleased to find us "carrying on so much research".

I confess that this remark of his struck me with rather profound surprise and the impression that it gave me is still rather vivid. We (the teachers and students in electrical engineering) were testing and investigating various strange or unfamiliar effects, but this was all in course of satisfying our curiosity regarding unexplained features of the instrumentali-

[1] Address delivered at opening session of thirty-ninth annual meeting of the Society for the Promotion of Engineering Education, Lafayette, Indiana, June 17, 1931.

ties in our field of engineering life. I presume that none of us had thought of it as "research". Research at that time rested in my mind as something leading up to a multiple volume treatise like Faraday's "Experimental Researches", Maxwell's "Electricity and Magnetism" or Helmholtz's "Sensations of Tone"; or perchance culminating in revolutionary discovery, like Faraday's researches in electromagnetic induction or Newton's investigation of motion and gravitation. Our activities were simple investigations carried on to satisfy inquiring minds and executed in the daily life of a group of students preparing themselves for their professional work. If these activities were research, it seemed an inevitable conclusion that research is a part of engineering education. The conclusion is sound. Research not only has a function in engineering education, but it is more, it is an integral part of properly conceived engineering education.

The recorded early part of the lives of Michael Faraday, Joseph Henry, George Stephenson, Alexander Holly and a host of others to whom we are indebted for the present status of engineering and the engineering industries shows plainly that the principal quality of their education, which primarily was self-education, arose from just such activities as were characterizing the electrical engineering laboratories in the University of Wisconsin to which I have referred. It was truly education to such men—in some instances almost the only education they secured in youth; it also was research of moderate order and Dr. Thurston was right in dubbing as research the activities going on in our Wisconsin laboratories.

However, I prefer to call such rudimentary or elementary research an exercise of the spirit of inquiry or scientific curiosity, and make the latter a definite feature of engineering education, to which it pertinently belongs. Phenomena and their interrelations command the engineering life, which is thus distinguished from the more arithmetical life of a merchant-prince or a country banker. Inquiry regarding phenomena may be analytical in character, calling for pencil and paper. It perchance may be philosophical in nature, calling for argument or debate. But such inquiry is most fruitful when originally unfolded in the laboratory, or the validity of its analytical or philosophical conclusions have been tested there. The laboratory of physical experiment is an eminent aid to the analytical and philosophical inquiries by affording pragmatic tests of the soundness of original analysis or philosophical synthesis, besides also of itself being a place for original discovery. Words alone are not enough. The individual must exercise the habit of seeing and investigating for himself.

Joseph Henry one time nicely stated in words one of those platitudes that ought to be commonplace elements of every engineering teacher's processes, but too often are forgotten because they are only platitudes: "There is a great difference between reading and study; or between the indolent reception of knowledge without labor, and that effort of mind which is always necessary in order to secure an important truth and make it fully our own." The crystallized hindsight of the printed text-book page and the conventional classroom lecture do not alone stimulate most minds to the necessary effort; but a ready instrument for such stimulation lies in the practice of investigation carried out under sympathetic counsel and direction by suitable leaders. For sufficiently advanced students the seminar consisting of a student group, carrying on research under the guiding influence of lectures by a professor, mutually discussing their inferences and conclusions, also perhaps testing them in the laboratory, and writing dissertations summarizing results of their inquiries, is a practice of proved success in higher education.

This is an age when most intellectual individuals prefer to command a great project rather than to inscribe a Greek verse, and this mental attitude has brought large rewards to the common people of the world as well as to the individuals who have dared on their behalf to deal with nature in new ways. The fine arts and the decorative arts lose no distinction by sharing their pedestal with the products of creative-minded men who concentrate their attention on those things that contribute to the physical welfare of the human race. Indeed, this sharing has brought to the graceful arts an incense of appreciation which has steadily broadened without sacrifice to its depth. The scientists and engineers lead the van of the daring ones, but none will "dare" except he possesses an investigatory spirit and a resourceful mind. If formal education is to do much for such men in their youth, as we claim is a prime object of engineering education, the education must be directed to research of the varieties that encourage the spirit of inquiry and add to the store of intellectual and manipulative resource. Lacking this, our disciples will not be among those who lead in the conquest of unknown regions and the marginal areas that face the engineering industries—which conquest may, decade by decade, confer yet larger and more widely-spread benefits on the common members of the human race. Book learning, and instruction about facts of nature and man, are a background for stimulating intelligence and arousing ambition, but alone they are static and insufficient to stiffen the students' backbones and inspire them to balanced initiative, originality and self-reliance.

The boon of such stiffening and inspiration, along

with lessons in the joys of accomplishment, may be conferred on our students by leading them into the paths of research, minor and easy paths at first but becoming more excitingly difficult according to the advancement of each student. The achievement of this process is difficult. Nevertheless, experience shows that the effort is worth while and observation indicates that the greatest centers of engineering education have become great and attractive to ambitious students because of willingness in those centers to make the effort.

Such reflections are fully supported by experience and observation. They may be verified by examples. The department of electrical engineering at the Massachusetts Institute of Technology and the like department at Cornell University share the honor of directing the earliest established formal curricula in electrical engineering. The world's practice in this field has largely grown from these two examples. These early curricula were both established in the academic year 1882–3, one late in 1882 and the other early in 1883, and students in each first received degrees in course in June, 1885. In those days the action of electrical machinery was not altogether understood and often was crassly misunderstood; the characteristics of electric circuits under transient conditions had not been extensively explored; equipment was meager; instruments for measurement were inadequate; text-books were not available; and instruction, as a matter of necessity, was by the seminar type of study and investigation carried on by students under direction of the professors. Some lectures were provided, but mostly the students studied the character of machines, instruments and circuits in the laboratories and reflected on the possibilities and consequences of modifications. Much extemporization was exercised to demonstrate the results of changes in combinations. If a machine or device was lacking and could not be borrowed in some form, students made it. The data for complete mathematical analysis were lacking, and the possibilities of many forms of analysis, now in common engineering use, were only showing over the horizon as an absorbing stimulus to individual ambition and study. The setting was one of vital and whole-souled intellectual interest. Examining the rosters of men who were in the early classes of these two courses discloses a notably high proportion of their members who became of high place in electrical engineering.

At a somewhat earlier date President Morton, Professor Thurston, Professor De Volson Wood and their associates at Stevens Institute of Technology were developing a similar situation in mechanical engineering. In that period Professor Thurston established a laboratory for investigation in the engineering sciences. Nowadays we would call it a research laboratory. These men were trail breakers in mechanical engineering education, and it may be significant that the roster of early graduates of Stevens now reads like a "Who's Who" in Mechanical Engineering. The influence of those graduates during the unfolding of American industries has been tremendous and magnificent. Still earlier, a devoted group at Rensselaer Polytechnic Institute worked through a similar development period in civil engineering education; and the large influence ultimately impressed by their students on American engineering is sufficiently well known.

These examples are typical and selected without overlooking the meritorious results from other early engineering schools and curricula established in the last half of the nineteenth century. Perhaps the interesting influence in chemical engineering of the courses of study in that branch that came into being a quarter of a century ago, or thereabouts, partly arises from a similar set of conditions growing out of applications of science in newly growing industries, which stimulated inquiring minds and led instruction through the paths of investigation.

Many of our present students will be inspired to mature performances just as notable as those of their predecessors, but can we unqualifiedly assert that those thus achieving will comprise an equally large proportion of the present generation of students as in the examples above referred to? I think that it is generally agreed that the answer to this question is "No." It may be lightly commented that now there are more students in the engineering schools and that they are less ambitious and scholastically less well prepared to pursue their courses of study in engineering; but this is not a sound rebuttal. There now are more engineering schools and many more professors employed in them, compared with the numbers at the close of the nineteenth century. Are we ready to concede less intellectual vitality, devotion and ability in the individuals of our group of teachers than in the corresponding group of forty years ago? That would be an ignominious confession. In my opinion there is as much intellectual vitality, devotion and ability per unit in our group to-day as there was forty years ago. The information disclosed in Vol. I of the Report of the Board of Investigation and Coordination of this society supports the opinion:

> The educational standards of the present group of engineering colleges taken collectively compare favorably with those of all other equally comprehensive groups of undergraduate colleges. This statement holds for the adequacy of their physical facilities, the number and qualifications of their teachers, the level of their ad-

mission requirements, the content and rigor of their curricula, the soundness of their scholastic standards, the extent and quality of their research activities, and their expenditures per student.

I will add the comment that an investigatory spirit and achievement are more important attributes for the engineering teacher than higher degrees, and we must fix our faces unwaveringly against a policy, now somewhat established in the colleges of arts, of making staff appointments from doctor's degrees attached to second-rate men in preference to selecting first-rate men without the doctorate when the first-rate man can not be secured along with the doctorate. You must remember when I say this that I am an active proponent for the advantage that graduate study confers on those who go into teaching and also for many of those who go into industrial life. But there are good reasons why a doctor's degree, as a badge, is not an important requisite for a teacher of engineering subjects. The man with neither fire nor industry is but loss in this occupation. Even where location and means preclude formal organization of research, this character in the teaching needs be kept foremost in the minds of the teachers. The opportunity for its exhibition is not lacking in any of our properly administered engineering schools. It should be the object to saturate our students in an aura of resourcefully productive thinking and doing. Plenty of this aura must emanate from the spirit of those who teach the classes, to be effective on the students, and not be the outcome alone of those who direct departmental affairs or those who confine their endeavors to formal research. Formal and external badges of learning, however carefully conferred, can not compensate for deficiency of these qualities in the teachers.

Observation leads me also to believe that our entering students are proportionately as well prepared to pursue their engineering studies as corresponding students were forty years ago. At the present time the number of listless students is numerically greater, but I doubt that the proportion of such in the total is greater, or that the preparation and ambition of most of the students are relatively less satisfactory, or that the proportion of adventurous intellectual spirits is less.

Students suitably infected with the spirit of investigation will smilingly carry heavy allotments of mental and physical work and ingratiatingly intimate a willingness for more. About eighteen years ago a large industry offered to the department with which I am related a considerable annual sum of money to be used over a period of improving our advanced instruction and research. We embraced the opportunity to keep the research so much in the consciousness of junior and senior students, as well as graduate students, that it has had a notably stimulating influence. Those of us in that setting think well of the result of this coordination of the teaching and research.

It also may be suggested that the field of the unknown has been exhausted in engineering and that there is nothing left for the inquiring mind, but that comment is only made by those who do not observe for themselves. It is sufficient to answer: Look around and observe, study the development of engineering in the past and present and you will discover a speed and width of the front of growth in all branches of engineering which now rivals if not excels any previous era.

This is a period suffering from a flood of predigested text-books, reliance on conventional laboratory assignments and presentation of formal lectures. The cry is made that these processes are necessary in order that the students may learn all that they should learn, and that there is no time left over for cultivating an investigatory spirit. My answer is that resourceful foresight and self-reliance (set against pepsinized hindsight and common industry) will always win in the end; and we develop the winner when we develop investigative spirit and resourcefulness, even if some store of secondary facts is neglected for lack of time. Our situation is illustrated by the old ditty:

> Could man but be sure that life would endure
> As of old, for a thousand long years,
> What things he could know, what deeds he could do,
> All without hurry or care.

Recognizing that life is short we must reconcile ourselves in education to selecting the most serviceable of various possible processes, remembering that the sweep of time does not permit us to embrace more. In making our choice of processes, however, we must try to make sure that the choice is of the most serviceable.

Albert W. Smith, known to most of you as former director of Sibley College, and before retirement as acting president of Cornell University, but to some of us known earlier as a remarkable teacher of machine design, held that no teacher should teach from a text-book written by another. This is a way of saying that the work of the engineering teacher should constantly grow under his hand; and also is a way of stating that the inquiring, forward-looking mind and the spirit of investigation are essentials to foremost engineering teaching. Unhappily, text-books written in that spirit often are received coldly by the teachers, as "too hard," and a preference is exhibited for the predigested, backward-survey types. This has a temporary justification among teachers

loaded with an excess of classroom assignments, but it is one of our collective duties as a society to show to college administrative officers a better way. Students who possess ambition and courage to study, reflect and learn under guidance ultimately may go far; but those who insist that they are paying their money "to be taught" are out of place in an engineering school.

Can any one doubt that the influence on their students and in engineering education of, for example, Irving Church, Mansfield Merriman and George Swain was in large part due to their resourceful originality and investigative spirit, standing foremost day by day as an example before their students? Engineers must deal with physics, economics and psychology, materials and forces, the philosophy of wealth (in the technical sense), and man. It is not a mental accumulation of facts alone that fits young men for doing this, but an understanding of interrelations of facts and the methods of detecting and identifying facts is of the essence. Our theories of action, relating to man or to mechanical design, are formulated from relatively few fundamental facts associated with a multitude of keenly recognized permutations of their relationships.

Detecting and identifying facts and discovering their varied relationships is research. Properly directed research is a potent instrument to arouse the ambitions and exercise the reasoning powers of students. It also teaches them to use foresight in planning and a responsibility for carrying through. It exposes them to early observation of the many faceted purposefulness and everlasting persistence of nature. It may result in important discoveries, which is another function. Universities and colleges (including engineering schools) have several functions to perform. One of these is the search for truth, and in science we interpret this as seeking for new facts, disclosing previously unobserved interrelations, and more fully illuminating facts and relationships previously announced but still partly obscure. In engineering we weave this function into a fabric along with economics and psychology and have a still more complex compass of research than characterizes any exclusive science. The field is magnificent and must be cultivated. Research is an inspiring part of the life of colleges. The spirit for establishing research laboratories and foundations in engineering schools is a presage of good educational spirit in the schools. The proper interpretation of the situation is important.

We must remember that universities and colleges have education for their prime function; and it being my thesis that research is part of engineering education, students of suitable advancement should be invited into the research precincts to there take up tasks. To set up research laboratories and libraries and bar out students of suitable advancement from pursuing work therein would be inappropriate to university ideals and to the weaving of the best fabric of engineering education. Research laboratories, dedicated to and carrying on fundamental research of high order, gloriously serve the advancement of mankind through their investigations and discoveries. When so directed that the atmosphere of independent achievement is allowed to spread into the haunts of upper-class students, as well as to graduate students and teaching staff, they collaterally make large contributions to educational results and thus their value to civilization is multiplied.

THE UNSOLVED RIDDLE OF THE SOLAR SYSTEM

By CARR V. VAN ANDA

NEW YORK, N. Y.

The public is being played upon and utterly misled by the dreamery of the rival mathematical astronomers and physicists.—*Professor Henry E. Armstrong, in Nature, Aug. 23, 1930, p. 275.*

DR. HAROLD JEFFREYS, university lecturer in mathematics and fellow of St. John's College, Cambridge, expounds in *The New York Times* of May 3 his newly developed theory that the planets of the solar system owe their origin to a shearing collision between the sun and another star. The article is a summary of two papers which Dr. Jeffreys contributed to the *Monthly Notices* of the Royal Astronomical Society, Vol. LXXXIX, Nos. 7 and 9, 1929. Because this theory, in contrast with its original rather unexcited reception by scientists, is now presented as something of exceptional importance; and because the present version indicates, as the original papers did not, an apparent final abandonment of Sir James Jeans's famous development of the "tidal theory," by the man who was long Sir James's chief supporter, an examination of both theories may prove to be worth while.

The essential feature of the new theory is that at the end of the collision there was drawn out between the two bodies a ribbon of matter in which circulation had been set up by their opposed velocities. This ribbon presently broke up and the parts condensed

into planets, endowed with rotation by the circulatory motion of the ribbon. Dr. Jeffreys assumes that the mass of the star was comparable with that of the sun and that their surface of separation approached the center of the sun within a distance equal to about half the sun's radius. In the absence of any assignment of definite mass and radius to the star, we shall in this discussion provisionally take them as equal to the sun's.

In the first of the original papers Dr. Jeffreys says that "the velocity of escape of a particle from the sun's surface is 450 km/sec.," and that the relative velocity of the sun and the colliding star would be of this order, or 400 km/sec. This figure for relative velocity still stands, two years later, in his article in *The New York Times*. Parabolic velocity for a particle at the surface of the sun is 620 km/sec., not 450 km/sec., as Dr. Jeffreys states, and for a large body like a star it would be much greater—about 875 km/sec. in the case here considered. So we have the parabolic velocity for a particle understated by 170 km/sec., the larger parabolic velocity for the star ignored, and a relative velocity assumed that is less than half the actual parabolic velocity. It is difficult to understand how Dr. Jeffreys reached the conclusion that such planets as ours could have emerged from conditions which would imply that the star was a permanent member of the solar system. If the laws of motion of two bodies did not provide sufficient evidence of such an association in this case, we should still have Dr. Jeffreys's word for it. Discussing the tidal theory, on page 26 of the second edition of "The Earth," he says: "But the velocity of the sun relative to the star was at all instants greater than the parabolic velocity, otherwise the sun and the star would still be associated." The necessity for a larger relative velocity is made strikingly apparent when, taking it at 400 km/sec., it is found that the collision would have established the sun and the star in an elliptic relative orbit, of which the major semi-axis would have been less than the sun's radius. In such an orbit the sun and the star would have tended to revolve in contact until they merged into one body—a process likely, however, to have been disturbed by internal reactions. The possibility that in the collision theory Dr. Jeffreys may have had in mind the sun in another than its present state is excluded by his assignment to it of its present mass and radius.

Dr. Jeffreys has made an important correction as to the duration of the collision. In the original paper this was given as about half an hour, arrived at by dividing the radius of the sun by the relative velocity —an error that leaps to the eye. He now writes: "The star would travel the diameter of the sun and be clear again in about an hour." This greatly affects the planet-forming mass that "trailed off after the star," at the end of the collision, and other elements of the problem as well. He gave this mass originally, and gives it now, as equal to 1/500 of the mass of the sun, but, by his own formula for one of its factors, as will be shown below, doubling the distance traveled by the star during the collision would double the thickness and mass of the planetary ribbon. It would also double the volume and mass of an equivalent sphere of the same density.

The rotational period of the "equivalent sphere" is employed by Dr. Jeffreys to show that his collision would impart a sufficient rotational period to the great planets. One of the chief difficulties in all theories of the origin of the solar system is that of securing for the planets, originally fluid, their observed rotation, or, indeed, any rotation at all. It is because he thinks it offers means of solving this difficulty that Dr. Jeffreys now revives the collision theory, 180 years old, of Georges Louis Leclerc, Comte de Buffon, who, in addition to theorizing about everything, translated Newton's Fluxions into French, and thereafter, quite appropriately, died of calculus.

Dr. Jeffreys writes the equation

$$\pi\rho a^2 d.du = \frac{8}{15}\pi\rho b^5\omega,$$

where the left-hand member is the angular momentum of the layer of matter displaced by the collision to form the planetary ribbon, the axis being taken as passing through the center of mass and perpendicular to the general motion, and the right-hand member is the rotational angular momentum of the "equivalent sphere"; ρ the density, a the radius of the sun, d the thickness of the layer, whose mass varies with it; u the relative velocity of the sun and the star, b the radius of the sphere and ω its angular velocity. This equation reduces to

$$\omega = \frac{a^2 d^2 u.}{\frac{8}{15}b^5}.$$

On his original calculation this led to a rotational period of 8 hours for the "equivalent sphere." There is, however, in the published paper a curious tangle of errors that seriously affects his result. In determining d, the radius of the sun is treated as the diameter of the interface formed by the star's passage through the sun—or, as Dr. Jeffreys puts it, the distance traveled by the star (within the sun's boundary, of course) during the collision—but it is also treated both as the radius and as the diameter of the interface in factors which determine b; and, in raising b^3 to b^5 from the equation $b^3 = \frac{3}{4}a^2 d$, the numerical coefficient $\frac{3}{4}$ has been carried unchanged into the denominator of the formula, making 4/3, instead of $(4/3)^{5/3}$, a factor

of the angular velocity. There is, besides, a considerable error in the final computation, due to the use of round, instead of accurate, numbers. The correction of the errors mentioned reduces the period to about 6½ hours, but is of no consequence while the assigned relative velocity remains so small as to assure the permanent association of the sun and the star.

Dr. Jeffreys is free to assign a larger relative velocity, but if he does so he will diminish the duration of the collision, increase the angular velocity of the "equivalent sphere," and correspondingly reduce its rotational period, the approximation of which to the 10-hour rotational periods of the great planets he seems to consider important. When all corrections are made, including the necessary increase in the relative velocity and the substitution of the true dimensions of the interface—these, as newly assigned by Dr. Jeffreys, are still incorrect—it is found that the rotational period of the "equivalent sphere" falls to about 2½ hours, or only one fourth the value aimed at.

Even if Dr. Jeffreys's assigned values had been such as to make the rotational period of the "equivalent sphere" equal to the observed average rotational period of the great planets—which would have required the relative velocity of the sun and the star to be less than 220 km/sec.—the plausibility of the demonstration would have been illusory. For it is readily shown that if the mass and the angular momentum of such a body had been distributed proportionally to form several spheres, including the great planets, the rotational periods of the latter could not have been, as they are now, nearly equal, but would have differed widely, and all would have been much less than they are observed to be.

Substituting in the formula for the angular momentum of the planetary ribbon the corrected values of various factors, which the present discussion has shown, or will show, to be necessary, the least possible value for the relative velocity—875 km/sec., in the case considered—would have given to the planetary ribbon an angular momentum of $8.13(10^{46})$ c. g. s. units. Neglecting the insignificant participation of the smaller planets, this is 10¼ times the total rotational angular momentum of the four larger planets, which is, by a computation that necessarily leads to a highly excessive result, $7.94(10^{45})$ c. g. s. units. The rotational angular momentum of each of the great planets is computed as if it were a homogeneous sphere of the same mass and mean radius as the planet. Thus the considerable increase of density toward the center is not taken into account. The true rotational angular momentum of each planet and the total for all the planets are therefore much less than they are computed to be. If data existed for an exact computation, the ratio 10¼ might be doubled, or even tripled. Taking the mass of the ribbon as equal to about 1/500 of the sun's (why this is correct, in spite of Dr. Jeffreys's conflicting data, will be shown below), it would have contained a little less than 1½ times the mass of the great planets. Thus a minimum of more than seven times their total rotational angular momentum would have been available for them. Its distribution in proportion to mass—any other distribution would have to be accounted for—would imply that the planets came into being rotating so fast that their equatorial surface velocities of rotation would have exceeded the parabolic velocities, or so-called "velocities of escape." The result would have been for Jupiter 1¼ times, for Saturn 2.4 times, for Uranus 9.6 times, and for Neptune 8.7 times the parabolic velocities at their respective equatorial surfaces. The effects of such a distribution of a little more than two thirds of the ribbon's angular momentum among the great planets, if it could occur, are shown in the subjoined table. The data used in the calculations are those given in Russell, Dugan and Stewart's "Astronomy."

	*Angular Momentum of Rotation		†Velocities Compared		Rotational Period	
	Observed, less than	By theory	Rotational at equator, by theory	Velocity of escape	Observed (Hours)	By theory (Minutes)
Jupiter	6.59	39.8	74	60	9.83	98
Saturn	1.28	11.9	87	36	10.23	66
Uranus	.04	1.8	202	21	10.7	13
Neptune	.03	2.1	200	23	15 ?	13?
	7.94	55.6				

* The numbers in the first two columns, multiplied by 10^{45}, represent c. g. s. units.

† The numbers in the third and fourth columns represent kilometers per second.

The great disparities revealed by the table show that the fundamental assumptions of the theory prohibit the formation of planets. It is possible that Dr. Jeffreys's formula overstates the angular momentum of the planetary ribbon. But any reduction which might be effected by correction of the formula would probably be more than offset by the reduction that an accurate computation, if it were possible, would make in the rotational angular momentum of the great planets.

If we accept Dr. Jeffreys's formula for the angular momentum of the planetary ribbon, a relative velocity of 125 km/sec. for the sun and the star would have enabled it to supply to a system of planets the total

rotational angular momentum of our system. In his recent article Dr. Jeffreys said his theory was supported by new mathematics only recently made available. If he has any mathematics that will reconcile the necessary reduction of the relative velocity to 125 km/sec., to equip our planetary system with the correct rotational angular momentum, and the equally necessary increase of that velocity to 875 km/sec., to dissociate the sun and the star after the collision, he possesses something that reduces the theory of relativity to insignificance as a modifier of Newtonian mechanics.

If the difficulties thus far described could be removed, would the mass of the supposed planetary ribbon be adequate to the formation of our planetary system? This mass is fixed by a quantity which, as Dr. Jeffreys points out, has been "determined by experiment"—the pure number .002, coefficient of a product of factors of the problem determining the thickness of the layer to which the opposed velocities of two fluids may communicate vorticity, when the difference of the velocities is high, as it is in this case. The mass of the ribbon is the product of the area of the interface and the thickness and density of the displaced layer. The momentum communicated to the layer in time t is $.002\rho u^2 t$ per unit area, where ρ is the density, which is taken as approximately equal to the mean density of the sun. But ut equals the distance traveled by the star during the collision. To this quantity Dr. Jeffreys originally gave the value a. Substituting this value in the formula for momentum, he found that a velocity u would be communicated to a layer whose thickness was $.002a = d$. Using this value of d in his formula for the mass of the layer, $\pi\rho a^2 d$—here, as will be seen, the diameter of the interface has been doubled, without explanation—that mass becomes $.002\pi\rho a^3$. Dividing this by the mass of the sun, $\frac{4}{3}\pi\rho a^3$, the mass of the planetary ribbon comes out 1/666 of the mass of the sun, instead of 1/500. Since he now doubles the distance traveled during the collision, making it $2a$, instead of a, he doubles the value of ut, and so doubles the thickness and mass of the layer. The mass should now be 1/333 of the sun's, instead of 1/500.

There is, however, another discrepancy to be considered, which also affects the mass of the planetary ribbon. Dr. Jeffreys says of his estimates, "All rest on the assumption that the area of contact had a radius comparable with the radius of the sun." So he writes the area of the interface equal to πa^2, giving it a radius equal to that of the sun. But the interface, whose center he places approximately at the midpoint of the sun's radius, would have a radius of about half the chord perpendicular to the sun's radius at that point, that is, about $.866a$. This is comparable with a, of course, but if we substitute its square for a^2 in πa^2, we reduce this factor of the planetary mass to its proper value, which is three fourths of that given by Dr. Jeffreys. The quantity ut is now the diameter of the interface, or $1.73a$, and the momentum will impart a velocity u to a thickness $.00346a = d$. Using this new value of d in the formula for the mass of the layer, and remembering that $.75a^2$ must be substituted for a^2, the mass of the layer becomes $.0026\pi\rho a^3$. Dividing this by the mass of the sun, we find the final corrected total mass of the planetary ribbon to be equal to 1/513 that of the sun. This is practically the value Dr. Jeffreys gave two years ago, which could not be obtained from the data he gave then; it is also his present value, which likewise, can not be obtained from the data he gives now, except with the corrections here indicated.

The curious agreement between Dr. Jeffreys's result and the one here derived, for the mass of the planetary ribbon, may have been due, in the first instance, to his taking the ratio of the two masses as roughly equal to his original 1-to-500 ratio of d to a, or to an accidental canceling of errors and omitted factors in his first calculation; but the fact that he left this value unchanged in his recent article, notwithstanding the doubling of the distance traveled by the star during the collision, suggests that a revised calculation has led him to substantially the same result as that found here. In any case, it appears that a mass equal to 1/500 of the sun's would have been displaced to form the planetary ribbon, if the interface penetrated the sun to the midpoint of its radius and the average density of the matter adjacent to the plane of the interface equalled the mean density of the sun. On the latter point Dr. Jeffreys says: "Its density would be comparable with the mean density of the sun" (second paper, p. 737); and he had previously taken the final density to be "the same as the initial one" (first paper, p. 640). These and other parts of his discussion indicate that in estimating the penetration of the interface and the average density in its neighborhood he has taken into account the compression that would occur during the collision.

The computed mass of the displaced layer, although it is about 1½ times the mass of our planets, is nevertheless inadequate to the formation of our system. As the two bodies began to separate, the layer, suddenly released from compression, would expand transversely and much of it might be lost in interstellar space; and under various conditions, the planets, if any were formed, might go to the star or be divided between the sun and the star. Moreover, it will appear when Jeans's theory is discussed—and

largely by Dr. Jeffreys's own contributions to that theory—that the formation of our system of planets would require the extraction of much more than their mass from the sun. The collision theory, like the tidal theory, requires not only matter enough to form the planets, but an allowance for such matter as would fall back into the parent body and an additional allowance for the "resisting medium," whose function it is to modify the highly eccentric original orbits of the planets. Each of these allowances, in the tidal theory, requires, as we shall see, a mass about equal to the mass of all the planets, and these requirements, at least for the resisting medium, can not be much less in the collision theory.

If the planetary ribbon "stretched out all the way from the sun to the star," "or three times the radius of the sun," as Dr. Jeffreys says, there is no apparent reason why, at its rupture, a system of planets should not have formed around the star as well as around the sun. If the division of the ribbon between the two were equal and none of the matter were lost in interstellar space, the part available for the formation of the planets in the solar system could hardly have been more than 1/1000 of the sun's mass, or almost exactly the mass of Jupiter.

It should perhaps be noted that when Dr. Jeffreys derives the duration of the collision from a division of the diameter of the interface by the relative velocity, we have taken his meaning to be something that might be called "effective duration." Actually, from the moment of making to the moment of breaking contact, under the conditions laid down, a star of equal mass and radius with the sun would travel twice the diameter of the interface. But the duration of contact and the density of the displaced layer, which has been averaged and treated as constant, both vary from zero to a maximum value for different parts of the interface, so as to affect the same mass as if the density were constant, the area of contact that of the interface, and the duration very nearly that required to traverse the diameter of the interface.

JEFFREYS'S WORK ON THE TIDAL THEORY

It may be instructive to consider for a moment Dr. Jeffreys in his now abandoned rôle of upholder of Sir James Jeans's theory that the planets condensed from a stream of matter drawn out of the sun by the gravitational power of a passing star, without contact. In this theory some restrictions have to be imposed upon the mass and density of the passing star. Jeans holds, in the only example he has given, which is "made to order" to fit the theory, that a mass twice the sun's is sufficient, at a proper distance, to draw out of the sun enough matter to form the planets.

Jeffreys reduced Jeans's theory to an extremely simple formula. Representing the mass of the sun by M, that of the passing star by M', the radius of the sun by a, and the distance between the centers of the two bodies at closest approach by R_0, he wrote:[1]

$$\frac{M'}{R_0^3} > \frac{M}{2a^3},$$

saying: "This is the condition that the mass M shall be broken up." It is extraordinary that upon arriving at this formula its author did not at once reexamine its foundations or abandon Jeans's theory. For hardly more than inspection is required to discover that, unless M' is much greater and of much higher density than M, R_0 will be so small that a collision must occur. If we test the formula, assuming the density of the sun and that of the star to be equal, we shall find that if M' be less than 57 times M, there would be a collision. At the latter value of M' the two bodies would make a momentary grazing contact at a point on their normal surfaces. We have here neglected the tidal protuberances on both bodies. To prevent their contact the value of M' would have to be far greater.

Obviously we require a star of higher density, which will permit a more reasonable value for its mass. Since the formula is general it should apply to all cases. Jeans takes

$$M' = 2M, \qquad R_0 = 2.667a,$$

and, grant him the sun he describes, apparently it will be ruptured and matter will be extracted from it. These values of M' and R_0 should satisfy Jeffreys's inequality, provided Jeans and Jeffreys are really using the same theory; instead, the least value of M' comes out about $9.5M$. A star of this mass and of the density necessary to avoid contact with the sun, and with its tidal protuberance, would probably have to be especially created. Jeffreys says his formula is the equivalent of each of two inequalities which he has just previously developed, one for a "slow" and one for a "transitory" encounter. It is the equivalent of the "slow" inequality, but the equivalent of the "transitory" inequality would have 2.22, instead of 2, in the denominator of the second term. The difference this makes is considerable, reducing the $57M$ and $9.5M$ of the above computations to $35M$ and $8.5M$, respectively, but not improving the prospect of finding the required star among such stars as are known. The encounter that would produce planets is described as lying between the "typically slow" and the "typically transitory." Unfortunately, Jeffreys bases his "transitory" formula upon an arbitrary requirement that the velocity of the outermost particle of the tidal stream, at the end of the encounter and

[1] "The Earth," second edition, 1929, pp. 24–25.

relative to the center of the sun, shall exceed the parabolic velocity of a particle at the normal surface of the sun. So a large and important part of the stream—the very part from which Jeffreys says the planets must be formed[2]—having originally a postulated parabolic velocity relative to the star, and being now endowed with an additional more-than-parabolic velocity, this time relative to the sun, would escape from both the star and the sun and be lost in space.

To illustrate the working of the theory, Jeffreys offers, as Jeans does, only a single example. In this he gives the sun nearly 1,000 times its present radius, the star 4 times the sun's mass, and makes the distance between the centers of the two bodies, when rupture of the sun ends, only 1½ times the sun's radius. Applying a formula derived from Jeans's work to determine the height of the tidal stream at periastron, it appears that Jeffreys's star, besides having to be of very high density, would be enveloped by the stream—bombarded by part of it, left behind by other parts—and possibly would acquire a system of planets for itself from the later parts having less than the assigned parabolic velocity. Whether such a sun as that described would acquire a system of planets is not important, for on the next page of "The Earth" (second edition) Jeffreys virtually admits—because, of course, of the new view of the age of the earth—that our sun could not have been in the condition described, when our planets were formed.

Thus Jeffreys's mathematical presentation has never offered the possibility of the formation of planets from the sun we know. Further, we see that Jeffreys and Jeans have all along been in disagreement, although, apparently, neither knew it until recently; for, until 1929, when the second editions of both Jeffreys's "The Earth" and Jeans's "Astronomy and Cosmogony" were issued, they were felicitating each other on having arrived at the same results. Agreeing or not agreeing, the results obtained by both have now been abandoned by Jeffreys.

JEANS'S WORK ON HIS OWN THEORY

It is well known that when Jeans proposed the tidal theory he assumed that the "birth" of the planets had occurred early in the history of the sun, to which he therefore assigned a radius equal to that of the present orbit of Neptune. Recent estimates of the age of the earth, placing it at a few thousand million years, a brief period compared with the age now attributed to the sun, constrained both Jeans and Jeffreys to the conclusion that the size of the sun could not have been appreciably greater when the planets were evolved than it is now. Neither Jeans nor Jeffreys offered new proofs to meet this new condition, although new proofs were very much needed. In the 1929 edition of Jeffreys's "The Earth" and in both the 1928 and 1929 editions of Jeans's "Astronomy and Cosmogony" there are paragraphs reducing the sun of the encounter to its present dimensions, but no change is made in the mathematics and reasoning, which clearly apply only to a sun of much larger radius and much lower density. So Jeans's work can be studied only in his original example.

Nowhere in the published works of Jeans and Jeffreys is any estimate given of the quantity of matter extracted from the sun during the tidal encounter, so that we have no assurance that after rupture occurred enough matter would be supplied to form our planetary system. Let us attempt a provisional estimate for Jeans's example.

Jeans gives no simple formula, as Jeffreys does; he does not even assemble the data in any one place. These must be searched out in the pages of his "Problems of Cosmogony and Stellar Dynamics." The quantities required, together with the numbers of the pages of the book on which they are to be found, are as follows:[3]

Mass of the sun, p. 277	$M = 2(10^{33})$ grams.
Mass of passing star, p. 277	$M' = 2M = 4(10^{33})$ grams.
Periastron distance, p. 284	$R_o = 1.2(10^{15})$ cms.
Radius of the sun, p. 278	$a = 4.5(10^{10})$ cms.
Critical distance between centers of the two bodies, when rupture of sun begins, p. 278	$R = 1.27(10^{15})$ cms.
Length of major semi-axis of sun in excess of a, at end of encounter, p. 130	$2fM'a/R_ov^2 = 2(10^{14})$ cms.
Relative velocity of M and M', p. 283	$10(10^5)$ cms./sec.
Time of encounter, p. 130	$2R_o/v = 2.4(10^9)$ seconds (about 76 years).
Constant of gravitation	$f = 6.66\ (10^{-8})$ c. g. s. units.

By the formula $2fM'a/R_ov^2$ we find that at the end of the encounter, which is taken to be at closest approach (periastron), the apex of the tidal stream is $2(10^{14})$ cms above the normal surface of the sun, or $6.5(10^{14})$ cms from the center of the sun. Let us assume that the tidal stream was separated from the sun where the attraction of the sun and the star, at periastron, just balanced. This is about $5(10^{14})$ cms from the center of the sun. The distance thence to the outer limit of the stream is $1.5(10^{14})$ cms.

[2] "Only the parts first drawn off can be permanently detached from the sun."—"The Earth," second edition, p. 20.

[3] An attempt has been made to reconcile the notations of Jeans and Jeffreys. These are almost identical, but Jeans is not always consistent, *e.g.*, using R both in the sense here conveyed and in the sense of R_o. For the a used here he uses r_o, and employs a for extensions of r_o, that is, for the major semi-axis of the tidally distorted sun. The formula $2fM'a/R_ov^2$ has been obtained by clearing the first term of Jeans's equation of its denominator and inserting in the numerator the gravitation constant, which Jeans here omits but afterward restores.

At the moment of rupture of the tidal cone the radius of a plane section of the solar spheroid at right angles to the major semi-axis and distant from the point of rupture $1.5(10^{14})$ cms would be about $2(10^{14})$ cms. As the sun approached periastron and matter continued to pour out, the tidal cone would be elongated and narrowed. So then, if we take a cone with radius of base $2(10^{14})$ cms and altitude $1.5(10^{14})$ cms, its volume should exceed that of the matter extracted by the star's gravitational pull, although its shape would not be that of the tidal stream.

This volume is $6.285(10^{42})$ cm.[3] Jeans gives the density of the tidal stream, or "filament," as he calls it, as $5.5(10^{-13})$ gm/cm.[3] Multiplying this by the volume, we obtain the mass of the matter extracted, $3.456(10^{30})$ grams, which is about 1/580 of the mass of the sun, or about 1.3 times the mass of all the bodies now revolving around the sun.

It has been pointed out in the discussion of the collision theory that in order that a planetary system may be formed, much more than its own mass must be extracted. The "resisting medium" necessary, according to the theory, to reduce the original eccentric orbits of the planets to their present shapes must be taken into account. According to Jeffreys,[4] it would be "reasonable" to compare the mass of the resisting medium with that of Jupiter, which is nearly three fourths of the mass of all the planets together. Since it is now known that there is a ninth planet, and possibly other planets, beyond Neptune, it may not be unreasonable to take the mass of the resisting medium as equal to that of all the planets together.

The extracted matter is also subject to other losses. It is agreed that much of it must have fallen back into the sun. The theory derives the rotation of the sun from this source, and Jeffreys[5] estimates that a mass at least equal to that of Jupiter would be necessary for this purpose. He calculates, of course, effective mass. Since it is probable that much of the matter that fell back would be ineffective in producing rotation, this estimate, too, might well be raised to an amount equal to the mass of all the planets.

A source of possible loss not considered by either Jeans or Jeffreys is radiation pressure. The importance of this would depend upon the conditions of the encounter. This pressure would be effective, if at all, against the resisting medium, which is supposed to consist of the lighter parts of the tidal stream, greatly rarefied by diffusion. The mean density of a comet has been estimated at 1/230,000 that of air,[6] which makes it $5(10^{-9})$ gm/cm.[3] It is a commonplace that when a comet approaches the sun the radiation pressure of the latter drives off in the opposite direction the matter emitted by the comet. Jeffreys[7] tentatively offers the hypothesis that the density of the resisting medium might be as low as $4(10^{-15})$ gm/cm[3], which is about 1/800,000 that of a comet. If radiation pressure from the star, or from the star and the sun combined, drove the resisting medium away, the cosmogonists would have to find some other means of reducing eccentric orbits.

So it appears that the various elements of the tidal theory require the extraction of hardly less than three times the mass of the planetary system to assure its formation. We have, therefore, a deficit of 1.7 times the mass of the planets in Jeans's theory. Actually the total mass extracted from the sun would probably be much less than the mass of the planets, and the deficit, therefore, so much the greater. For, in order to give the theory every chance, we have chosen a crude method of estimate intended to give a result far in excess of any mass that could be extracted by tidal forces alone. Even if more matter than we have here allowed could be extracted, the radial velocity of the additional part would be so insignificant that it would probably be only so much more that would fall back into the sun.

Jeans's mechanism for starting his planets in revolution around the sun is contradicted by himself. On page 284 of "Problems of Cosmogony," he "supposes" that the tidal filament is set in motion so that it rotates as a straight line around the sun with an angular velocity of $4(10^{-10})$. This would give, at a distance from the sun's center equal to 2.1 times the radius of Neptune's orbit, "the transverse velocity appropriate to the description of a circular orbit," so that "planets formed at a less distance than this would describe eccentric orbits."

But he has previously shown that the stream of matter can not rotate in a straight line. After the end of the encounter it is bent around by the star's gravitational pull into the shape of a boomerang. Nothing is given to show that the lagging parts of this curve would ever acquire the transverse velocities necessary to maintain orbits around the sun.

If the theory rested upon so insecure a basis when Jeans fitted to it an imagined sun, so moulded to his purpose that probably such a sun never could have existed in reality, how hopeless it becomes when applied to the sun of a few thousand million years ago that did not differ appreciably from the sun we see to-day. When we compute the parabolic velocity for the present sun and a passing star of twice its mass, at distance $R_o = 2^2/_3 a$, and add 22 per cent. for safety, as Jeans did in his example, the required relative

[4] "The Earth," 1929, p. 60.

[5] *Monthly Notices*, R. A. S., May, 1929.

[6] Russell, Dugan and Stewart, "Astronomy," Vol. 1, p. 430.

[7] "The Earth," second edition, p. 60.

velocity of sun and star rises to 800 km/sec. Such an encounter might cause a convulsion, or a series of convulsions, in the sun, but the most optimistic cosmogonist could hardly expect it to produce planets according to the tidal theory in its present form.

Gravitation requires time to raise any considerable tidal elevation. Jeans's theory could be effective, if at all, only when the sun had a very large radius and correspondingly low density, as all his work shows. These conditions permit a wide separation of the centers of the two bodies, which reduces the velocity necessary to prevent their union in a system, and so tends to gain the required time.

In "Problems of Cosmogony and Stellar Dynamics" and in "The Earth," Jeans and Jeffreys, respectively, professed to rest their case on tidal forces alone, yet there have been manifestations of a disposition to beg the question by tacitly assuming the aid of unnamed forces. Both constantly use the term "ejection," which implies propulsion rather than attraction. This term has been replaced here by "extraction," as more appropriate to a purely tidal theory. "The second star outdoes the sun in gravitational pull, and the top of the [tidal] mountain *shoots* off toward it," says Jeans.[8] The lid has been lifted and the "shooting" has been going on for more than fifteen years in Jeans's one example, but his formulae for distance and velocity at the outer end of the "filament," at the end of this period, represent only gravitational acceleration, taking no account of "shooting."

It may be asked at this point: "Should not internal forces be considered in applying the theory to the sun as at present constituted?" To this the answer is: Certainly, if any one knows what those forces are and how they would behave under tidal provocation. Chamberlin and Moulton, of the University of Chicago, long before Jeans and Jeffreys had begun to deal with the subject, evolved a theory which employed both tidal forces and such internal forces of the sun as they were aware of. To their "planetesimal hypothesis," against which Jeans, Jeffreys and many others have directed destructive criticism, Jeans owes the concept of the extraction of matter from the sun by the tidal pull of a passing star. If he intends to take over another element of this hypothesis, it will be interesting to see how far new knowledge may enable him to surpass his predecessors in handling the combination. As to new knowledge, is it to be found in the bewildering contradictions of the debate, now in its third year in the Royal Astronomical Society and in the scientific journals, about what goes on inside a star? If not, there is always available as an alternative the fundamental principle of Jeffreys's collision theory—which the debaters have not paused to heed—that nothing goes on inside a star that need trouble a determined planet builder. Or is Sir James Jeans, indeed, about to abandon his tidal theory altogether and adopt the collision theory of Buffon, as developed by Dr. Jeffreys? We find him expressing the belief, in *The New York Times* of so recent date as June 7, that "the earth is merely a tiny fragment of the sun, which got splashed off [the exact idea of Buffon], almost by accident." The mathematician of Cambridge, rejoicing, no doubt, in an exchange of rôles, would welcome the support of a recruit so distinguished and powerful as the mathematician, poet and dreamer of Dorking.

There is no intention of offering here a theory to replace those that have been considered, but perhaps the cosmogonists will permit the suggestion that, in the tidal theory, they have left half the field uninvestigated. All have set out on the assumption that the planets must have come out of the sun and that, therefore, the encounter must have been with a star more massive than the sun. The sun may have encountered a smaller star of rather low density, quite as easily. If the mass, density and velocity of the star could be so nicely adjusted that, as it swung round at perihelion, the outer part would slide off in a barely hyperbolic orbit, leaving a sufficient part of the remainder with less than parabolic velocity, and therefore under permanent bonds to keep pace with the sun, the tidal theorist, at one happy stroke, would acquire the mass necessary for his purposes, with rotation thrown in by the slide. Or, suppose the sun had encountered a nebula? What would have happened in that case?

August 7, 1931.—It may be interesting to note that after the last question had been written, and before it could be published, an answer had been given. *Nature* (July 25, p. 156) records the fact that Mr. K. Hirayama, of the Tokio Observatory, has published in the *Proceedings of the Imperial Academy of Japan* (7, No. 5, 1931) an investigation of the effects of the impact of a star with a spherical nebula. Mr. Hirayama, according to *Nature*, concludes that if the relative velocity were barely hyperbolic before impact, it might be reduced by the impact below the parabolic value, so that the consequent elliptic relative orbit, because of the frequent overtaking of one mass by the other, might be steadily reduced by repeated impacts, at each of which a part of the nebula would be detached and captured by the star, the final result being the formation of a planetary system.

There seems to be no reason why the argument should not equally apply if the encountering bodies were the sun and a star of less mass and much lower density. The establishment of such a theory as to encounters of stars with smaller stars or with spher-

[8] "The Stars in Their Courses," 1931, p. 41.

ical nebulae would do much to destroy the idea, sedulously fostered by Jeans, Jeffreys and others, that our system is unique. It may be possible to demonstrate that stars of mass and density so high as to be capable of rupturing by gravitational power alone masses comparable with the sun, are extremely rare or non-existent; but there is no evidence that bodies small enough to be ruptured by approach to or contact with such stars as the sun have not existed in the past, or do not still exist, so that practically all large stars may have had, or may yet have, each its own planet-feeder. For the peace of the timid, it is to be hoped that nobody will suggest that the job in our system is not finished and that the remains of the sun's planet-feeder may be expected back to complete its disturbing mission.

OBITUARY

RUSSELL A. OAKLEY

DR. RUSSELL A. OAKLEY, principal agronomist in charge of the Division of Forage Crops and Diseases of the Bureau of Plant Industry, U. S. Department of Agriculture, died at Monrovia, California, on August 6. He was born on a farm near Marysville, Kansas, on September 7, 1880, and graduated with a B.S. degree from the Kansas State Agricultural College in 1903. After a short period of graduate work in the University of Chicago, he accepted an appointment as scientific aid in the Department of Agriculture and served continuously in that department from July 16, 1903, until the time of his death. Because of the excellent service rendered during the war period as chairman of the Seed Stocks Committee and of his recognized ability as an agronomist, the Iowa State College upon the recommendation of President Pearson conferred upon him in 1920 the degree of Doctor of Science. He was later elected fellow of the American Association for the Advancement of Science and of the American Society of Agronomy.

Those who knew Dr. Oakley best will remember him always as one who possessed to a remarkable degree the quality of making friends and as one endowed with almost superhuman courage and cheerfulness in long years of struggle with physical infirmities on account of arthritis. His associates never ceased to marvel at the indomitable will which enabled him to go about his work day after day uncomplaining and efficient. This heroic attitude toward his afflictions was not the result of any religious belief or any tendency toward asceticism; it came rather as the result of his unconquerable spirit refusing to surrender and always "playing the game."

This brief description of the personality of Dr. Oakley should add lustre to his achievements which are recounted in more detail in other journals. It also accounts for his recognized success as an administrator. The Department of Agriculture entrusted him with numerous assignments in the administrative field. From 1913 to 1926 he was in charge of the Office of Seed Distribution of the Bureau of Plant Industry, and in addition during the war period served as chairman of the Department Seed Stocks Committee; for several years he was assistant chairman of the Federal Horticultural Board and continued up to the time of his death as a member of the Advisory Federal Plant Quarantine Board. Since 1926 he has been in charge of what is now the Division of Forage Crops and Diseases. During much of the latter period he served as chairman of the Research Committee of the U. S. Golf Association Green Section. He also performed with credit to himself and the department several special assignments of the Secretary of Agriculture.

His research activities in agronomy were confined mostly to investigations with alfalfa and turf grasses. He is co-author with the late C. V. Piper of a book "Turf for Golf Courses," and with Dr. Piper originated and edited for many years the U. S. Golf Association *Green Section Bulletin*. Dr. Oakley is author of many department bulletins and articles in scientific journals. He leaves behind a splendid record of achievement.

H. N. VINALL

MEMORIALS

WE learn from *Nature* that in view of the approaching centenary celebration of Clerk Maxwell, the Cambridge University Press announces a book of essays written to commemorate the event by Sir J. J. Thomson, Dr. Albert Einstein, Dr. Max Planck, Sir Joseph Larmor, Sir James Jeans, Sir Ambrose Fleming, Dr. W. Garnett, Sir Richard Glazebrook and Sir Oliver Lodge.

A COMMITTEE, as reported in the London *Times*, has been formed to organize the appeal for a British national memorial to Sir Joseph Wilson Swan (1828–1914), who, apart from many lesser inventions, was the first to invent and introduce for practical purposes the electric incandescent lamp. Swan was also a pioneer in photography and the processes of photographic printing. The Institution of Electrical Engineers, of which Sir Joseph Swan was president in 1898, is presenting to the Borough of Sunderland a bronze tablet, designed by Mr. R. A. Ray, which will be erected in the entrance hall of the Sunderland Central Public Library, Museum and Art Gallery. In

addition, a committee representing the institute and Swan's native town is appealing for a sum of £5,000 with which to found National Swan Memorial Scholarships in electrical engineering science. The fund will be administered by the Institution of Electrical Engineers, the interest being devoted to the payment of the scholarships.

RECENT DEATHS

DR. NORMAN BRUCE CARSON, professor emeritus of surgery in the Washington University Medical School, died on August 9 at the age of eighty-six years.

DR. JOHN S. FULTON, formerly director of the Maryland State Department of Health, died on August 12. He was seventy-two years old.

SAMUEL TOBIAS WAGNER, consulting engineer of the Reading Railway Company and professor of engineering at the Wagner Free Institute of Science, died on August 7 at the age of seventy years.

MISS SARAH G. FOOTE SHELDON, for over twenty-five years a volunteer full-time assistant to the late J. H. Paarmann, curator of the Davenport Academy of Sciences, now the Davenport Public Museum, died on July 2 at the age of about seventy-five years.

DR. WALTER E. DIXON, reader in pharmacology at the University of Cambridge, previously professor at King's College, University of London, fellow of the Royal Society since 1911, died at Cambridge on August 16.

PROFESSOR RICHARD WETTSTEIN, of the University of Vienna, director of the Vienna Botanical Gardens, died on August 10 at his estate, Triene, in the Tyrol. He was sixty-seven years old.

A REUTER message reports the death at Montreux of Professor Auguste Forel, who retired from the chair of psychiatry at the University of Zürich in 1897. He was the author of the "Social World of Ants."

SCIENTIFIC EVENTS

MEDIUMS FOR THE ISOLATION AND CULTIVATION OF BACTERIA IN THE FILTERABLE STATE

THE Northwestern University Medical School has issued a bulletin by Dr. Arthur I. Kendall, professor of research bacteriology, giving full details for the preparation of K medium for the isolation and cultivation of bacteria in the filterable state.

In the James A. Patten lecture, given on July 22 and printed in the issue of SCIENCE for August 7, Dr. Kendall made the first announcement of the discovery of a new method for the isolation of bacteria which hitherto have remained invisible. This was the development of a culture medium, which will change bacteria from invisible to visible form.

In the new bulletin issued on August 9, Dr. Kendall describes in detail how the K mediums are made from the tissue of the animal or human body. Intestine has been used chiefly for this purpose, although Dr. Kendall states that brain, liver, kidney, spleen and heart have been used. "Hog intestine," he writes, "has been distinctly more suitable than rabbit intestine and rabbit intestine has appeared to be more favorable than dog intestine. Human intestine which was not available when early studies were made is under investigation at present."

After full detail of the preparation of the mediums and commenting upon aspects of their use, Dr. Kendall gives the following conclusions:

The K mediums, protein rich and peptone poor, have afforded a direct method of approach to the purview of three highly important aspects of bacteriology which are mutually related and dependent:

First (theoretical), it appears to be a biological fact that many bacteria can, and do, exist in two states, filterable and non-filterable.

Second (clinical), bacteria may be isolated from the blood stream of patients suffering from diseases that have hitherto proved difficult or refractory to cultivation.

Third (intrinsic), homologous bacteria may be cultivated both from bacteriophage and from Besredka antivirus.

From the biological point of view, this demonstration of the filterable and non-filterable states of microbic existence not only opens new fields for exploration, it also offers reasonable explanations for many hitherto suspected, but unconfirmed phenomena of microbic activity. Thus, bacteria growing in K medium from stock cultures, thereby undergoing change from non-filterable to the filterable state, not only are separable by filtration into those not cultivable in ordinary mediums (the filterable forms) but also tend to differentiate rather readily into "smooth" and "rough" types (the non-filterable forms), which may be separated by plating directly upon agar mediums. Also, the filterable forms, recultivated upon agar, often may be separated into "smooth" and "rough" types.

Chemical studies already under way suggest that the respective activities of these filterable and non-filterable forms are quantitatively and possibly qualitatively unlike. It may be stated also that the first editions of non-filterable forms obtained upon agar are, or may be, materially less reactive than the fully acclimatized, non-filterable forms gained by repeated transfer.

Finally, perhaps the most transpicuous argument at

the present time against the plea of "leaky filters" as being an explanation for the existence of the filterable state of bacteria, is to be found in the oft repeated cultivation of homologous bacteria from various kinds of bacteriophage. Bacteriophage has been a subject of investigation in innumerable workshops. Two facts are quite universally agreed upon. First, that phage in an active state is filterable through the finest stone filters. Second, attempts to cultivate homologous bacteria from phage filtrates have been almost axiomatically unsuccessful. It is, however, a comparatively simple matter to obtain growth of the homologous "phaged" microbe in the filterable state in K medium. From this growth in K medium, direct cultivation at the proper time upon agar will yield colonies of re-phagable organisms.

THE LONDON SCHOOL OF HYGIENE AND TROPICAL MEDICINE

ACCORDING to the regular London correspondent of the *Journal* of the American Medical Association, the London School of Tropical Medicine, founded in 1899, has undergone great development in recent years, largely in consequence of the munificent gift of $10,000,000 from the trustees of the Rockefeller Foundation to enable the University of London to establish a center of postgraduate teaching and research in the science and art of preventive medicine. The idea that preventive medicine should embrace not this country alone but the whole world led to the incorporation of tropical medicine in the scheme. Hence the palatial buildings which were opened in 1929 by the Prince of Wales are called the London School of Hygiene and Tropical Medicine. The school is probably the most complete institution of the kind in the world. The staff is organized in six main divisions: public health, biochemistry, bacteriology, medical zoology, epidemiology and vital statistics, tropical medicine. The students form three main groups. A number varying between 70 and 100 come for a course of six months in tropical medicine and hygiene. Most of these are already in or desire to enter a public medical service in the British Empire or foreign countries. In a paper read before the Royal Society of Arts, Major Greenwood, F.R.S., professor of epidemiology and vital statistics, states that the course of instruction, partly clinical, partly laboratory training, makes considerable demands on their energy because much ground has to be covered in the time. The next largest group consists of students seeking to enter public health service and intending to sit for the diploma examination in public health of the University of London. This course is longer and takes a whole year, and it is possible to present the different aspects of a problem of disease more completely—the chemical, bacteriologic, parasitologic, epidemiologic and administrative sides one after another. Thus a sound knowledge of, say, the prevention of plague is obtained from various specialists. The third group consists of students specializing in one branch, such as bacteriology or epidemiology. It is said to include some of the best students, many of whom are foreigners. The division of epidemiology has already had students from thirteen countries.

THE RETURN OF "THE DISCOVERY"

THE London *Times* reports that *The Discovery*, Captain Scott's old ship, returned to London on August 1 and berthed at the East India Docks after two years in the Antarctic. Sir Douglas Mawson, the leader of the expedition, was not on board, having left the ship in Australia.

Captain K. N. Mackenzie, who is a native of Oban, said that a fine film of the voyage had been made, including many interesting scenes of penguins and icebergs. On arrival at Sir Douglas Mawson's 1910 camp in Cornwath Bay they found a tin of tobacco which had been lying there for over 20 years. It was in perfect condition, and with much amusement they watched Sir Douglas enjoy his first puff of this old mixture. The expedition had a number of dangerous experiences with icebergs in discovering seven hitherto uncharted regions. These new regions are Princess Elizabeth Land, MacRobertson Land, Bansarctic Land, Sabrina Land, Knox Land, Kemp Land and Enderby Land. Altogether, the expedition charted 1,000 miles of new coast line, which they flagged and claimed for Britain. One third of the whole of the Antarctic Continent was circumnavigated and 4,800 miles of Arctic water plied. The expedition collected data which has been left at Adelaide University, from which it is expected that several scientific discoveries of importance will be made. The slump in the whaling industry had given the whales a much-needed chance to survive, and the expedition discovered two new whaling grounds of first-rate importance.

Navigating Officer W. R. Colbeck, speaking of the blizzards experienced in the Antarctic, said that on one occasion the expedition encountered a hurricane off Adelie Land. The engines could not face it, and as a heavy sea was running they were drifting on to the edge of an ice pack. The sides of the vessel were badly battered. Later, the vessel was jammed in an ice pack for several days. The expedition went as far south as 68½ degrees, when they came to land and could go no further. Some special broadcast programs were sent out from Sydney on a short-wave length and were enjoyed very much. The expedition did a great deal of oceanographic work as a result of which 20 tons of specimens were obtained.

ADDITIONS TO THE HERBARIUM OF THE U. S. NATIONAL MUSEUM

THE National Museum, with more than 1,500,000 specimens of plants from all over the world, has recently acquired quantities of valuable specimens from South America, according to information recently given to a representative of the *U. S. Daily*.

Among these plants, it is expected, will be found many novelties. About 600 specimens have been brought to the museum by Mr. W. A. Archer, who has been collecting privately many varieties in the Choco region of northwestern Colombia.

Already supplied with a fine Asiatic collection and a good European collection, acquisitions from South America in the past year contributed by two explorers augment the specimens from this region. Many of these plants may prove to have scientific and economic value as the use to which the Indians put them medicinally suggests fertile fields for scientific analysis. However, the museum merely collects, identifies, classifies, and names the specimens, without attempting to experiment with them for scientific possibilities.

The National Geographic Society recently presented a large number of plants collected by E. G. Holt in an expedition to the Upper Orinoco. For several months his expedition was attached to the Brazilian-Venezuelan Boundary Commission, and from this heretofore inaccessible border region the greater part of the collection was taken.

The last trip conducted by the Smithsonian resulted in collecting 9,200 plants. Mr. Archer has contributed about 3,000 to the museum, representing private expeditions by him into Colombia.

The South American collection is growing rapidly. Prior to 1920 there were only two or three collections from this area. Since, the expeditions have been conducted in cooperation with Harvard University and the New York Botanical Garden. Three expeditions have been made into Colombia, two to British Guiana, and two to Ecuador. These journeys were made by the museum as part of a cooperative plan of collecting.

SCIENTIFIC NOTES AND NEWS

THE Baly Medal of the Royal College of Physicians of London, conferred every alternate year on the person who shall be deemed to have most distinguished himself in the science of physiology during the two years immediately preceding, has been awarded to Professor W. B. Cannon, of the Harvard Medical School.

THE honorary degree of D.Litt. will be conferred in December by the University of Liverpool on Dr. James Rowland Angell, president of Yale University, formerly professor of psychology in the University of Chicago.

PROFESSOR KASIMIR FAJANS, professor of physical chemistry and head of the chemical laboratory at Munich, has been made an honorary member of the Royal Institution of Great Britain, a distinction which has been conferred on several other German scientific men including Professor Einstein, Professor Ostwald, the chemist, and Professor Laue, the physicist. Professor Fajans gave the George Fisher Baker lectures at Cornell University in 1930.

THE Silver Leibnitz Medal of the Prussian Academy of Sciences has been awarded to Dr. Karl Scheel, professor of thermodynamics at Berlin, and to Dr. Agnes Bluhm, of the Kaiser Wilhelm Institute for biology.

THE *Journal* of the American Medical Association reports that Dr. Edward O. Otis, of Exeter, New Hampshire, formerly of Boston, was recently honored by more than a hundred physicians, nurses and health workers at a special meeting at the headquarters of the Boston Tuberculosis Association to commemorate the fiftieth anniversary of his service in that field. Dr. Otis, who is an honorary president of the Massachusetts Tuberculosis League and a former president of the National Tuberculosis Association, was presented with a purse of gold on behalf of the league. Speakers on this occasion included Drs. Frederick T. Lord, George H. Bigelow, state commissioner of health, and John B. Hawes II. Dr. Otis, who is eighty-three years old, is also professor emeritus of pulmonary diseases and climatology at Tufts College Medical School.

DR. ALBERT H. MILLER, associate editor of the *Rhode Island Medical Journal*, Providence, was recently awarded the Fiske Fund Premium for his essay entitled "Anesthetics—Their Relative Values and Dangers." Established ninety-six years ago by the will of Dr. Caleb Fiske, one of the early presidents of the Rhode Island Medical Society, the fund provides for an award to the author of the best essay submitted each year and for the subsequent publication of the essay.

LORD BALFOUR, of Burleigh, has been elected president of the British Royal Sanitary Institute, in succession to the late Duke of Northumberland.

MR. GILBERT T. RUDE has been appointed chief of the Division of Marine Operation of the U. S. Coast and Geodetic Survey.

DR. KENNETH M. WATSON, formerly professor of chemical engineering at the University of Wisconsin, has joined the research and development staff of Universal Oil Products Co. Dr. Watson's headquarters will be at the Universal's Riverside Laboratories, Chicago.

THE Oregon State Board of Higher Education has appointed Dr. A. B. Cordley, who has served the state for thirty-six years, for the past twenty-three years as dean of the School of Agriculture of Oregon State College, dean emeritus of the school. During Dr. Cordley's service as entomologist and plant pathologist of the experiment station, according to the resolutions adopted by the board, he made three outstanding discoveries that have been the means of adding great productive wealth to Oregon, namely, (1) his discovery of the life-history of the codling moth under Oregon conditions, and of a successful method of control; (2) his discovery of the cause of apple-tree anthracnose and of a control method; (3) his invention and development of the method of stock solution of lime-sulfur spray for control of apple scab.

THE Maryland State Department of Health has selected Anne Arundel County as the site for an experimental health service which, according to the state health director, Dr. Robert H. Riley, may lead to the establishment of a model full-time health department. Dr. John H. Janney, Jr., of the Rockefeller Foundation, has been named director of the new unit. The cost of the experimental department will be $20,000 annually, which is about twice the cost of the average county health department. It will be borne by an appropriation of $5,000 by the county commissioners, $7,000 advanced by the State, and the remaining $8,000 contributed by the Rockefeller Foundation and the Johns Hopkins School of Hygiene.

DR. WILLIAM W. JAMESON, professor of public health in the London School of Hygiene and Tropical Medicine, has been appointed dean of the school, succeeding the late Sir Andrew Balfour.

MR. E. C. TITCHMARSH, of Balliol College, Oxford, has been elected to the Savilian professorship of geometry, vacated by the resignation of Professor G. H. Hardy.

DR. A. F. JOSEPH has retired from the deputy directorship of the Imperial Bureau of Soil Science, a post which he has held since the inception of the bureau in May, 1929.

THE Ramsay Memorial Fellowship trustees, London, have made the following awards of fellowships for 1931–32: Mr. B. K. Blount, a fellowship of £300, tenable for two years, at the University of Oxford; Mr. Ragnar Ericson, civil engineer, a Swedish fellowship of £300, tenable for two years, at the Imperial College, London; Dr. George Karagunis, a Greek fellowship of £400, tenable for one year, at University College, London; Dr. J. Lens, a Netherland fellowship of £300, tenable for two years, at University College, London; Dr. Y. Urushibara, a Japanese fellowship of £400, tenable for two years, at University College, London. The trustees have renewed the following fellowships: Mr. W. R. Angus, British fellow, University College, London; Dr. James Bell, Glasgow fellow, University College, London.

BY an order of the Committee of the British Privy Council, made after consultation with the Medical Research Council and with the president of the Royal Society, the Right Honorable Lord Dawson of Penn, president of the Royal College of Physicians, and extra-physician to the London Hospital, and Dr. Edward Mellanby, F.R.S., professor of pharmacology in the University of Sheffield, are appointed members of the Medical Research Council in succession to Professor T. R. Elliott, F.R.S., and Professor J. B. Leathes, F.R.S., who retire in rotation on September 30.

DR. NELSON W. TAYLOR, of the University of Minnesota, is conducting x-ray research during the summer at the Utah Engineering Experiment Station, Salt Lake City, in connection with the work on mineral physics which is being done there.

PROFESSOR R. B. THOMSON, of the department of botany of the University of Toronto, has resumed his work after a year's leave of absence spent mostly in the British West Indies.

DR. DARWIN O. LYON writes from Tripoli, expressing regret at sensational items that have appeared in the daily press concerning his work. Under the auspices of the Royal Meteorological Observatory of Libyia, he is at present making experiments with sounding balloons and rockets in order to get data on the temperature, density and composition of the atmosphere at great heights.

LORD MOYNIHAN, president of the Royal College of Surgeons of England, sailed for South America on July 24, to take part in the forthcoming medical conference at Buenos Ayres.

LECTURES recently given before the Scripps Institution of Oceanography at La Jolla, California, include one by Dr. F. S. Brackett, chief of the new

division of radiation and organisms of the Smithsonian Institution, on "The Study of the Effect of Radiation on Plants" and one by W. P. Kelley, of the division of agricultural chemistry of the Citrus Experiment Station at Riverside, California, on "Base Exchange in Soils."

THE following appointments of lecturers for 1932 have been made by the Royal College of Physicians: Sir George Newman, Harveian orator; Dr. Dugald Baird, Bradshaw lecturer; Dr. Harriette Chick, Oliver-Sharpey lecturer, and Dr. L. P. Jacks, Lloyd-Roberts lecturer.

PROFESSOR WILLIAM DOBINSON HALLIBURTON, emeritus professor of physiology, King's College, London, who died on May 21, provides in his will, on the death of his wife, £10,000 to the University of London, King's College, for endowment, or towards the salary of a professor in the subject of physiology or the sciences relating thereto.

THE *British Medical Journal* reports that the Kerckhoff Institute for the study of affections of the heart, built from a donation of a million dollars by Mrs. Louise E. Kerckhoff, of Los Angeles, as a memorial to her husband, has been opened at Bad Nauheim. The building, in classic style, consists of two main cubicle structures with a connecting wing. It contains an auditorium seating six hundred persons and intended for congresses, and a smaller lecture room. A medical library and a museum with representations of methods of treating circulatory disturbances, physical diagnosis and therapy, balneological collections, etc., are at the disposal of investigators. The institute will conduct special continuation courses open also to foreign physicians. It is divided into five main departments: one for patients sent to Bad Nauheim under the German social insurance system; a statistical department devoted to research into the causes of cardiac diseases; a department for educating the public as to causes and treatment of such diseases; another for their study and treatment; and a department covering treatment by physical methods, especially baths. Professor Groedel is at the head of the institute, for the maintenance of which Mrs. Kerckhoff has provided a fund of one million marks.

ACCORDING to *Industrial and Engineering Chemistry* progress in the plans for the erection of a headquarters building for American pharmacy, near the National Academy of Sciences in Washington, D. C., was reported at the seventy-ninth annual convention of the American Pharmaceutical Association held in Miami, Fla., the latter part of July. A total of $501,904.82 has been collected from pharmacists and the various branches of the drug trade, and over $315,000.00 more has been pledged to the undertaking. Plans have been drawn and approved, and actual construction is being held up only until the Commission of Fine Arts of the Federal Government completes its own plans for the development of that part of the District of Columbia where the site of the proposed building is located. An effort will be made to endow the building to the extent of one million dollars. It is planned to provide a permanent repository for historical material bearing on the profession of pharmacy, to supply research facilities as well as a pharmaceutical library second to none in the country, and office facilities for the various activities of the American Pharmaceutical Association. It is believed that construction of the building will be completed by the close of 1932.

EXCAVATION for the new building of the Eye Institute of Columbia University, which it is estimated will cost $1,100,000, has been started. It is expected that the building will be finished in about a year. The Eye Institute, which will be a part of the Columbia Medical Center, is to be an eight-story building at Fort Washington Avenue and 165th Street and is architecturally in harmony with the group occupying the area from 155th to 168th Streets and from Fort Washington Avenue to Broadway. The basement will be used for storage, service and x-ray rooms. The first floor will be used for administrative offices and for receiving patients. The next five floors will be devoted to bedrooms and wards. The operating and lecture rooms will be on the seventh floor and the laboratory will be on the eighth floor. Mr. James Gamble Rogers is the architect of the building.

The British Medical Journal reports that the American Medical Association of Vienna, which was founded in 1904, and is a society of English-speaking medical practitioners, publishes a useful "blue book" every two years. The new edition of this, which has recently appeared, contains a comprehensive list of the study courses available in Vienna throughout the year for those who have little or no knowledge of German. The society has arranged with prominent physicians and specialists of the University of Vienna to conduct special courses and provide private tuition as may be required, and on reasonable terms. About 4,000 medical practitioners have become registered members of the association since January, 1923; a quarter of these joined it last year, an indication of the rapid growth which is going on. Any medical practitioner arriving in Vienna as a total stranger, even though unacquainted with the German language, can, through its agency, obtain specialist instruction in any subject for periods of

any length. *Ars Medici*, the official monthly bulletin of the American Medical Association of Vienna, contains reviews and abstracts of the latest publications in foreign medical literature, special departments being devoted to German and Austrian medical research; a special section deals with the scientific and social activities in Vienna. Inquiries may be addressed to the secretary of the American Medical Association of Vienna at its headquarters, Alserstrasse 9, Vienna VIII.

THE London *Times* reports that at a general meeting of the British Society for the Preservation of the Fauna of the Empire, held on August 3 at the offices of the Zoological Society of London, with Mr. Speden Lewis presiding, the report of the executive committee was presented. It stated that since the last general meeting efforts had been begun to investigate conditions in Labrador, to ascertain whether one or more areas could be set aside as sanctuaries. The question of dispatching a mission of inquiry to West Africa had been proceeded with. The most suitable time for the dispatch of the mission would be about the end of November. For reasons of economy the Game Department of Nyasaland had been abolished. This was disappointing, for its constitution was in a great measure due to the representations of the society, and owing to the excellent warden appointed it had been a great success. Representations were being made in the proper quarter. They were also being made about the Indian rhinoceros, as information had been received that poaching in Assam had been intensified of late, and there was little doubt that unless it could be checked the vanishing point would soon be reached.

A RECENT survey by the Pennsylvania Forest Research Institute shows that the American chestnut, which seemed marked for destruction by a fungus blight which killed nearly every adult tree in the Eastern States some years ago, is recovering from the devastating attack of disease. New shoots from the roots of the trees that were killed by the fungus have been growing rapidly with every evidence of health and strength and the Pennsylvania Institute reports that a fairly good sized crop of chestnuts may be gathered this year from the young trees. The blight from which chestnut trees in the eastern United States have been suffering began in 1904, when it was first discovered in a park in Brooklyn. It rapidly spread until all the states from Maine to West Virginia were affected in varying degrees. In parts of the country practically all the native chestnut trees were destroyed.

AT the recent international jubilee meeting in London of the Society of Chemical Industry a plan was arranged for the cooperation between manufacturers of Great Britain, France and Germany. French and German scientists and industrialists visited the exhibition of British Chemical Plant, and it has been provisionally agreed that future exhibitions of this nature in the three countries shall be organized and advertised in close collaboration. Each country will take its turn triennially. France will hold her next exhibition in 1932, Germany will follow with "Achema" in 1933, and the exhibition will again be held in Great Britain in 1934. The representative organization in each country dealing with the manufacture of chemical plant will be responsible for organizing parties to visit the exhibitions held in the other countries.

DISCUSSION

THE SUMMER MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE IN 1933

THE Chicago Centennial is an international exposition under national auspices; but it is more than this; it is an intellectual occasion. Even if the exposition were devoted exclusively to economic and commercial exhibits it would be full of interest to all students of social science; for, after all, economics is really only the objective side of the great science of *how men live together*. The fact is, however, that the pure sciences have been given a fundamental position in the plan of the exposition, the principal theme of the undertaking being the dependence of industry upon the basic sciences.

Shortly after the American Association for the Advancement of Science decided to hold a summer meeting at Chicago in 1933, the trustees of the exposition decided to cooperate by providing for the invitation of a considerable number of men of science from foreign countries as guests of the meeting. Accordingly the Council of the American Association for the Advancement of Science was asked to suggest the names and proper distribution of these guests. At the Cleveland meeting, 1930, the following committee was charged with this duty: J. McK. Cattell (chairman), W. B. Cannon, H. Crew, B. E. Livingston, R. A. Millikan, T. H. Morgan, F. R. Moulton, W. A. Noyes. Meeting at the Cosmos Club in Washington, D. C., on April 27 and 28, the committee allotted a definite number of guests averaging about five to each of the fifteen sections of the American Association for the Advancement of Science. Suggestions as to individual scholars, men of marked

achievement, leaders of thought, were next sought from the various divisions of the National Research Council, as well as from the secretaries of the different sections of the American Association for the Advancement of Science and of certain societies of specialists. The response to these requests has been generous and, for the most part, prompt.

It is hoped that guests accepting the invitation will appear on the program of the association's meeting and will also be available for one or more public lectures in various scientific centers. For a number of years past the program of the American Association for the Advancement of Science has been a highly important one, even when limited entirely to the productive scholarship of America. The foregoing plan is intended to enrich the regular program and is felt to be in full harmony with the international character of the exposition.

No attempt will be made to give, in a single week, a cross-section of human knowledge: but it is believed that a bird's-eye view of the main lines of present-day research will be presented and will render the 1933 meeting a memorable scientific occasion. The aim is to establish personal contact between an intelligent audience and the leaders in science. The Century of Progress is the name under which this exposition is incorporated; but there is here no implication that it is a backward looking institution. The whole purpose is, indeed, to point the way to another coming Century of Progress, to demonstrate the unity and importance of science. Every effort will be made to eliminate from this meeting the turmoil and bustle of a world's fair by the selection of appropriate meeting places. But if, in these efforts, the local management is not in every way successful there will be compensations, illuminations of mind and matter, and foregatherings, which will leave the balance on the right side.

By action of the council of the American Association for the Advancement of Science at its recent meeting in Los Angeles, the exact date of the Chicago meeting was fixed as the last full week in June, 1933.

JOHN STEPHEN SEWELL
DIRECTOR OF EXHIBITS,
CHICAGO CENTENNIAL EXHIBITION

THE MARINE LABORATORY OF THE UNIVERSITY OF SYDNEY, AUSTRALIA

I HAVE just received from Professor W. J. Dakin, of the department of zoology, University of Sydney, New South Wales, Australia, a letter in which he informs me that, notwithstanding the great financial stringency in Australia he has succeeded in procuring funds for the establishment of a small temporary marine laboratory and the acquisition of an auxiliary yacht of 13 tons. Both the laboratory and the yacht belong to the department of zoology of the University of Sydney. A program of investigations without aid from the state is being carried out, although serious financial difficulties beset the University of Sydney. At present particular attention is being devoted to the plankton and certain hydrographic conditions to a distance of about five miles off shore east of Sydney. Already plankton catches have been taken regularly for eighteen months. Professor Dakin himself has been conducting experiments on the osmotic pressure of the blood of certain marine organisms apart from investigations that he has already made on "The osmotic concentration of the blood of *Callorhynchus millii* and *Epiceratodus* (*Neoceratodus*) *forsteri*, and the significance of the physico-chemical condition of the blood in regard to the systematic position of the Holocephali and the Dipnoi."[1]

Professor Dakin writes that his laboratory is very badly off for literature and that he is unable to raise more money to face the adverse exchange rates. He has asked help in obtaining literature, especially on the physical and chemical methods of oceanography and on plankton. It has occurred to me that by publishing this note in SCIENCE assistance for Professor Dakin's struggling laboratory might be procured. He says: "We are doing our utmost with private funds and often risking life too by working from inefficient boats on a most unruly because unprotected sea." Will those who are willing to send literature please address it as follows: Professor W. J. Dakin, Department of Zoology, University of Sydney, New South Wales, Australia. Any help that may be extended will be very greatly appreciated.

T. WAYLAND VAUGHAN
SCRIPPS INSTITUTION OF OCEANOGRAPHY

DEVELOPING NEW VARIETIES OF HOPS

LAST fall work was initiated to develop new varieties of hops. Because of an attack of downy mildew, *Pseudoperonospora humuli* (Miy. et tak.) Wils., it was desired to obtain new varieties which were not only resistant to this disease, but also superior in yield and quality. The variety Fuggles has been reported as resistant to this disease. This variety, however, under most Oregon conditions, is considered low in yielding ability and of a quality that is desired only by a certain trade.

Naturally fertilized seeds of this crop were collected in the growers' yards. Preliminary trials showed that the seed was dormant and would not grow under ordinary germinating conditions. The seed, therefore, was chilled for about ten days at freezing temperatures and then scarified by rubbing on coarse emery

[1] Zool. Soc. London, *Proc.*, pt. 1, pp. 11–16, April 14, 1931.

paper. This seed was planted in the greenhouse on October 9 in flats and the seedlings were transplanted to a bed after they had made a growth of about 12 inches. Artificial lights (three 500-watt Mazda lamps for 100 plants) were turned on from 5 to 12 P. M. each night. Plants 20 feet in length were developed by March 29, and two of the plants came into burr (blossom) at this date. A growth of 12 inches was recorded in one day. This development of a hop plant from seed to blossom in less than six months' time indicates the possibilities of rapid development of new varieties. Professor E. S. Salmon, in England, stated that the "work of raising new varieties of hops is an arduous and expensive one and is necessarily very slow, since the seedling plants do not bear a crop until the third year, and can not be judged for character such as aroma, richness in resins, and cropping powers until the fifth year, at the earliest."

The use of chilling and scarification of seed, the greenhouse and the lights are of great assistance in speeding up a program of breeding with a crop of this type. The striking variability of seedlings indicates a great difference in the value of the different plants. Of course, it will take additional time to test out not only their disease resistance, but also their yielding ability and quality. Also, some time will be required to increase their vegetative parts for planting stock.

This procedure not only speeds up the breeding program, but also gives available plants for testin in the spring when inoculum of the downy mildew disease, which is a true parasite, is plentiful.

E. N. BRESSMAN
OREGON STATE AGRICULTURAL COLLEGE

POLYEMBRYONY IN RED SPRUCE

IN the course of a germination test of red spruce *Picea rubra* (Link.) collected in eastern Maine in the fall of 1930, two well-formed radicles, each about 2 cm long, were observed protruding from the same seed coat. Unfortunately, upon removing the sprouted seed the root tips were damaged, so that it was impossible to grow the seedlings. Upon dissection two sets of well-formed cotyledons were disclosed. Both seedlings appeared to be of equal vigor, so that it seems probable that two normal seedlings would have developed, had they been undisturbed. Similar phenomena have been reported by Jacobs[1] in sugar pine, *Pinus lambertiana* (Doug.), in 1 per cent. of all seeds tested by him, and recently by Woodworth[2] in *Alnus rugosa* (Du Roi) Spreng, but the writers are unaware that polyembryonism has been recorded in red spruce. During nearly 300 tests of this species, aggregating over 30,000 seed, this has been the only case observed.

HENRY I. BALDWIN
WARREN E. PERCIVAL
BERLIN, NEW HAMPSHIRE

[1] Allen W. Jacobs, "Polyembryonism in Sugar Pine," *Jour. For.*, 22: 573–574, 1924.

[2] Robert H. Woodworth, "Parthenogenesis and Polyembryony in *Alnus rugosa* (Du Roi) Spreng.," SCIENCE, n. s., 70: 192–193, 1929.

ABBREVIATIONS FOR SCIENTIFIC AND ENGINEERING TERMS

NEARLY two hundred years ago an Englishman determined the value of π to 707 decimal places. One state legislature is said to have "standardized" the value of π as 3. Between these impracticable extremes lies the value which has served, and will continue to serve, the purposes of science.

As a matter of convenience, abbreviations have been established for many words which are in frequent use or which are cumbersome by reason of length. Many of these abbreviations, though not logically derived from the English words which they now represent, have been sanctioned by custom, and the period at the end is the generally accepted sign of an abbreviation. A chemical symbol is quite generally written without the period, and thus in present usage there is a distinction between C (for carbon) and C. (if that form be used for centigrade).

The list of "Abbreviations for Scientific and Engineering Terms" prepared by a sectional committee of the American Standards Association proposes to abolish the period, to change many of the time-honored forms of abbreviation, and in many instances to "standardize" two forms of abbreviation for the same word.

Elimination of the period is proposed "in the interests of economy and the reduction of waste." It is difficult to see how this will be realized. No economy of time is indicated in printing and proofreading where the printer is expected, for example, to set "cu m" (for cubic meter) and (in the absence of periods which determine the spacing) to decide whether cum or cu m is the proper form.

Though the American Association for the Advancement of Science is given as one of the organizations sponsoring this proposed list of abbreviations, the writer has consulted a number of association members without finding one who knew of the list, or who favors it in its present form.

If the list is to be sanctioned by the association, many members who are careful in their use of English will no doubt be interested in the proposed forms. The list appeared in the "ASA Bulletin" of July, 1930, and in a publication dated January, 1931, designated as "A. S. A. Z10i–1931."

The list is not a very long one, but its adoption

promises a long period of confusion. Somewhere between the complete word and the arbitrary and ambiguous form of abbreviation, there is a well-established tradition which should not be entirely ignored if wide-spread use rather than mere official adoption is to be achieved.

E. H. McCLELLAND
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SCIENTIFIC APPARATUS AND LABORATORY METHODS

THE MICROPHONE AMPLIFIER

IN the transmitter of the ordinary telephone, the vibrations of the diaphragm produce varying pressures upon carbon granules or a carbon button. The electrical resistance of the carbon varies with the pressure: so that an electrical current may be made to vary in accordance with the impressed sound waves. This current, although controlled by the sound vibrations, has much more energy. Hence, the carbon button acts as an amplifier for sound vibrations.

It is, therefore, possible to make use of the carbon transmitter as an amplifier for wireless signals. The circuit is shown in Fig. 1. The output from an ordinary detector valve AB is passed through the coils of a wireless receiving telephone. The type used in this circuit is a Brown telephone. The diaphragm of the Brown telephone is set in vibration by a little metallic reed which is itself actuated by the rectified current from the detector tube. The diaphragm of the Brown receiver is removed and a short light metallic rod is connected from the reed C to the middle of the diaphragm D of a telephone transmitter. Then when the reed vibrates in unison with the incoming signals the diaphragm of the transmitter D presses against the carbon button E. The current

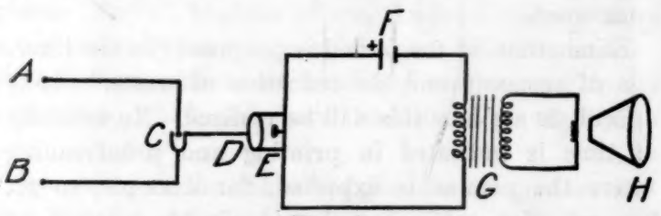

FIG. 1.

supplied from the six-volt storage battery F varies with this pressure. Accordingly a variable current passes through the primary of the audio transformer G. This causes a current in the secondary which actuates the loud speaker H. The audio transformer is inserted to prevent the direct current generated by the battery F from passing through the coils of the loud speaker.

This arrangement gives plenty of amplification, but the quality is rather poor. The device is not very sensitive, as the carbon button will not respond to weak vibrations.

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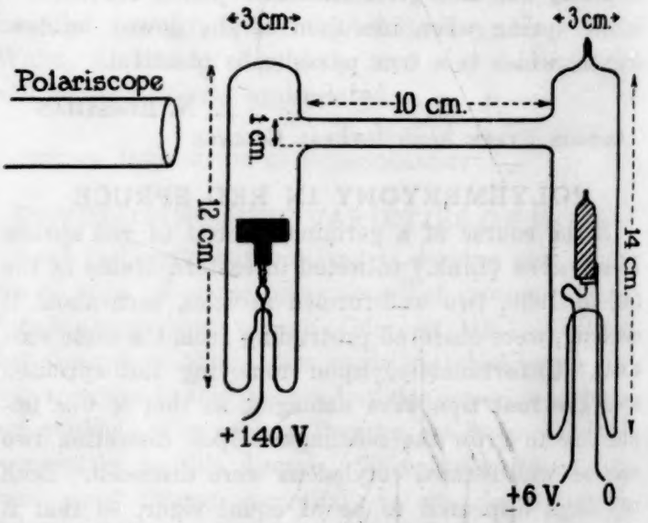
THE USE OF A HOT CATHODE HELIUM LAMP AS A SOURCE OF MONOCHROMATIC LIGHT FOR THE POLARISCOPE

A CONTINUOUS spectrum in conjunction with suitable prism and diaphragms is not well adapted for precise measurement of rotatory power. The mercury arc unfortunately gives only two lines suitable for polarimetric purposes ($\lambda = 5460.7$Å and $\lambda = 4358.3$Å). The two yellow lines, 5790.7Å and 5769.7Å, are too near to one another to permit an easy separation, especially as a great intensity is needed for measurements of rotatory power. The helium spectrum shows two intense lines, a yellow one ($\lambda = 5875.6$Å) and a red one ($\lambda = 6678.1$Å). The yellow line permits measurements of great accuracy and can be used to great advantage in place of the inconvenient mercury yellow lines. Furthermore, it presents a second advantage in being situated very near the sodium doublet for which the rotations of the majority of organic compounds have been determined.



Hot cathode helium lamp

Except for the red line furnished by the Cd arc, which is difficult to operate for routine work, there is no red light readily available which is intense and pure enough for the purpose specified. The helium red line is located very far towards the red and is ideal for measurements in that part of the spectrum.

With the lamp described above, the intensity of this line was such as to permit a reading within ± 0.015° with a half shadow angle of 4°. Using a photographic process the angle could be read within ± 0.003° (exposure 60 seconds, half shadow angle 4°).

Measurements with the yellow line 5875.6Å were consistent within ± 0.002°.

The lamp used, which is reproduced in the above diagram, was an all-quartz hot cathode helium lamp built by the General Electric Vapor Lamp Company, Hoboken, N. J. The arc was operated under 160 volts and carried 5 amperes.

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SPECIAL ARTICLES

ACTION CURRENTS IN THE AUDITORY TRACTS OF THE MIDBRAIN OF THE CAT

IN the course of an investigation of action currents in the central nervous system of the cat by means of an amplifier in connection with ear phones or a string galvanometer, responses were obtained from the auditory tracts of the midbrain. The intensity, timbre and pitch (up to at least 1,000 per sec.) of the sounds applied to the ears of the cat were reproduced with considerable accuracy in the ear phones. The observations of Wever and Bray[1] on the auditory nerve were repeated and their results confirmed. Adrian's observations,[2] which led him to suggest that the effect in the nerve is due to a diffuse electrical spread from the cochlea, have also been confirmed, but with the following qualification: (1) The responses are much greater in the auditory pathways than in the surrounding tissue. (2) There appears to be a decrease in the size of the responses upon the local application of narcotics.

We believe that the effect in the brain stem represents at least two elements: primarily, action currents in the particular auditory tract to which the electrode is applied; and secondarily, electrical spread from more distant parts of the auditory mechanism.

Our method allows stimulation of either or both ears. A stethoscope is fitted to the decerebrate cat. Its bell receives taps at constant rate and intensity. Voice or other sounds may be delivered through a funnel in place of the stethoscope bell. The sound may be localized to one ear or the other by clamping the appropriate arm of the stethoscope. A diffuse silver electrode is placed subcutaneously on the muscles of the skull and a differentiated electrode consisting of a fine silver needle, insulated except for the very tip, is pushed down the brain stem caudally at right angles to the planes of decerebration.

Sharpness of localization is characteristic of responses in the brain stem. Using the string galvanometer with one stage of amplification the responses are obtained *only* from certain points. A movement of the electrode of one millimeter or less suffices to pass through a maximum and usually to loose the response. With a more sensitive amplifier and ear phones this point represents a very sharp maximum, many times louder than the responses from neighboring points. These active points have been shown by subsequent gross section to lie invariably upon the auditory pathways, including the trapezoid body, acoustic striae, and lateral lemnisci up to the inferior colliculi. Numerous other regions explored, not on the pathways, have never given any response with the less sensitive apparatus.

When electrodes are placed upon crossed tracts, such as the lateral lemnicus, the responses are chiefly contralateral, *i.e.*, the electrode in the left midbrain is much more sensitive to stimuli applied to the right ear than to those applied to the left ear. This contralateral relationship agrees well with the known anatomy of the auditory pathways.

When the cat dies in the course of an experiment the responses from the brain stem are lost as soon at the heart stops beating, and sometimes a few minutes before. The responses from the acoustic nerve persist after those from the brain stem are no longer detectable, and sometimes for several minutes after the heart has stopped.

Narcotization of parts of the brain stem by injecting 5 per cent. or 10 per cent. novocaine in Ringer's solution near the electrode obliterates responses on the string. The responses return after one to three hours. If the novocaine is injected on one side of the brain stem between the electrode and acoustic nerve, responses from that ear disappear, while those from the other ear persist.

Comparison of responses from the acoustic nerve with those from the brain stem shows that those from active points in the brain stem are usually slightly greater than those from the nerve. This is true even if the electrode pierces the sheath of the nerve, thereby yielding greater responses than if on its surface.

[1] E. G. Wever and Charles W. Bray, SCIENCE, 71, 215, 1930.

[2] E. D. Adrian, *J. Physiol.*, 71, 4: 1931.

Words are always reproduced more clearly and intelligibly from the nerve. Those from the brain stem, while often intelligible, are always somewhat blurred. There is some doubt as to whether the upper limit of pitch is as high for the brain stem as for the nerve.

We believe that the above evidence indicates that we are dealing with true action currents in the auditory pathways. It demonstrates the possibility of direct study of the activity of individual tracts within the central nervous system, by such methods as have been employed for peripheral nerves and the cerebral cortex.

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THE EFFECT OF HYPOPHYSECTOMY ON GESTATION IN THE RAT[1]

EXPERIMENTAL work on the functions of the pituitary gland has dealt largely with the effects of extirpation of this gland on growth and on the development of the reproductive organs, and, with the exception of the early work of Aschner on pregnant dogs, no further studies seem to have been carried out on the effects of hypophysectomy on the maintenance of pregnancy in mammals. It seemed of interest, therefore, to see what effects, if any, removal of this gland would have upon the course of gestation in the rat.

A total of 43 pregnant rats were operated on for the removal of the anterior and posterior lobes of the pituitary gland. The age of the rats at the time of operation ranged from 92 to 247 days, the average being 126; while the day of pregnancy varied from the eleventh to the twentieth, most being within the twelfth to the sixteenth.

Of the 43 operations, 21 resulted in the incomplete removal of the gland, for at necropsy it was easy to find under a dissecting binocular small pieces of anterior lobe, or of anterior and posterior lobes, *in situ*.

In all the foregoing 21 rats, gestation ended in parturition, the young in most cases being alive. In 18 of these rats the gestation period was of normal length, and all the newborn were living and were suckled. Pregnancy in the other 3 animals was prolonged. One mother gave birth to 2 living young and 3 dead on the twenty-fifth day, one of the litter showing signs of having milk in its stomach. On necropsy a very small piece of the anterior lobe was found to have been left. The second mother gave birth to one dead and one living young at 11 A. M. on the twenty-fourth day of pregnancy. Three hours later two more living young were found in the cage. The following morning all were dead, apparently without having been suckled by the mother. The mother was killed the same day and was found to contain *in utero* one macerated foetus, and at the site of the pituitary a small piece of the gland. In the third case, on the twenty-fifth day one was found born alive. Necropsy revealed no others *in utero*, although there was evidence of others probably destroyed after birth. Traces of pituitary tissue were found.

Twenty-two of the 43 pregnant rats used in the experiment retained none of the pituitary. Microscopic findings will be reported later. In all these the period of pregnancy was lengthened by from 3 to 4 days. With two exceptions, noted below, the mothers died without being able to give birth to their young. One of the two exceptions was sacrificed on the twenty-sixth day in order to secure good necropsy material. In the other exceptional case, the young were removed by caesarian section on the twenty-fifth day, the result of which was that the mother recovered. At necropsy a month later, the former site of the pituitary showed no traces of the gland, and the ovaries, uterus, thyroid and adrenals exhibited all the characteristics of a completely hypophysectomized animal.

The evidence at hand thus shows that complete removal of the pituitary is followed by death at the end of a prolonged pregnancy, unless, as in one case, the mother's life is saved by removal of the foetuses from the uterus.

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[1] Aided by a grant from the National Research Council.

BOOKS RECEIVED

BAUR, ERWIN, EUGEN FISCHER and FRITZ LENZ. *Human Heredity.* Translated by Eden and Cedar Paul. Pp. 734. 171 figures. Macmillan. $8.00.

Bureau of Commercial Fisheries, Division of Fish and Game of California. Handbook of Common Commercial and Game Fishes of California: Lionel A. Walford. Pp. 183. 137 figures. The Striped Bass of California: Eugene C. Scofield. Pp. 84. 47 figures. The Commercial Fish Catch of California for the Year 1929: The Staff of the Bureau of Commercial Fisheries. Pp. 155. 75 figures. Studies of the Length Frequencies of the California Sardine: California State Fisheries Laboratory. Pp. 53. 25 figures. California State Printing Office.

EDGE, A. B. BROUGHTON and T. H. LABY, Editors. *The Principles and Practice of Geophysical Prospecting:* Being the Report of the Imperial Geophysical Experimental Survey. Pp. ix + 372. 261 figures. Cambridge University Press, Macmillan. $5.00.

FELIX, EDGAR H. *Television, its Methods and Uses.* Pp. x + 272. 73 figures. McGraw-Hill. $2.50.

SMITH, WALTER B. *The Jones Cove Shell-Heap at West Gouldsboro, Maine.* Pp. 28. 26 figures. *The Lost Red Paint People of Maine.* Pp. 43. 29 figures. Lafayette National Park Museum.